HyPra: Characterizing the Rotation-Activity Relation At 600 Myr With K2 Light Curves And Ground-Based Spectroscopy

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Forty years ago, Andrew Skumanich proposed that rotation and chromospheric activity, a proxy for magnetic field strength, decrease at roughly the same rate for solar-type stars between the ages of 100 and 500 Myr. The existence of an age-rotation-activity relation (ARAR) has generated hope that measurements of rotation and/or activity can be used to obtain the ages of field stars. Unfortunately, however, a robust, quantitative, theoretically motivated description of the ARAR still eludes us.

Empirical forms of the ARAR rely largely on observations of stars in open clusters: these stars' well-defined ages make them valuable targets for measuring rotation periods and indicators of magnetic activity such as Halpha line strengths and X-ray luminosities. However, ages derived from empirical ARARs rarely have uncertainties better than 50%. Open clusters are relatively rare, particularly at older ages, so that calibrating the ARAR between a few 100 Myr and the age of the Sun is difficult. And until recently, there was little overlap between the clusters used to measure periods and those used to measure activity. Rotation studies often focused on distant clusters, whose smaller angular sizes maximize the number of stars whose periods can be measured efficiently with multi-epoch imaging of a few fields. Activity studies targeted nearby clusters, for which high signal-to-noise data can be obtained with single-object spectroscopy or in all-sky X-ray surveys.

Over the last several years, we have engaged in a large-scale campaign to systematically map out rotation and activity in open clusters ranging in age from 35 Myr to 3 Gyr. Our focus is on calibrating the ARAR for low-mass stars, which dominate most stellar populations by number and have lifetimes exceeding the age of the Galaxy. As every low-mass star formed in the Milky Way still resides on the main sequence, using an improved ARAR to derive reliable ages for these stars would provide invaluable insight into the chemical evolution and star formation history of the Galaxy. Furthermore, the first habitable Earth-like planet is likely to be discovered around an old, low-mass field star: understanding this planet's radiation environment and current habitability will require an improved ARAR that can be applied to its parent star. Currently, however, we must invert the process, adopting canonical ages for the field-star population to constrain the ARAR

Recently, we examined the relationship between activity and rotation in the Hyades and Praesepe, two benchmark, roughly 600-Myr-old clusters. Because these are two of the nearest, best-studied open clusters, empirical calibrations of the ARAR often interpolate directly between the observed properties of their members (and particularly of Hyads) and those of the Sun. We found that the Hyades and Praesepe follow an identical color-activity, and therefore age-activity, relation, implying that we can use the merged HyPra sample to characterize stellar properties at 600 Myr (Douglas et al. 2014).

We propose to obtain K2 light curves for every accessible HyPra member. The K2 campaign is an extraordinary opportunity to complete the sample of period measurements for stars in these two clusters, providing access to longer, lower-amplitude signals than can currently be measured from the ground. In addition, the K2 campaign will allow us to disentangle real stellar variability from some of the systematic effects that plague ground-based period measurements. Combining the K2 data with existing and new spectroscopy, we will provide new constraints on the operation of stellar dynamos and calibrate a valuable tool for age-dating stars and exoplanets. This proposal therefore directly supports NASA's goal of understanding exoplanetary systems.